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Supporting the Development of Professional Competencies and Engineering Identity at Scale

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Supporting the Development of Professional Competencies and Engineering Identity at Scale

Work in Progress Paper

Introduction

Experiential learning opportunities have long been known to be important in higher education [1] as they have been linked to more successful recruitment and retention efforts and better career placement [2]. Experiential learning is thought to result in a change in judgment, knowledge, or skills, or the development of professional competencies and identity [1]. The Global State of the Art in Engineering Education report [3] identified experiential learning opportunities as a key pedagogical feature of engineering education. Perhaps this emphasis stems from experiential education's alignment with engineering design education efforts [4], its potential to support the development of professional competencies [5], [6], or its ability to produce more innovative, career-ready engineers [7]. Within engineering education, experiential learning opportunities can include participation in engineering design and competition teams, study abroad, professional and honor societies, scientific research [3], or identity-based organizations [8].

In engineering education literature, experiential education has also been studied for its potential to support professional formation via engineering identity development [9]. Engineering identity, a concept that describes how students understand themselves as engineers, has been argued to be a significant indicator of educational and professional persistence [10], [11]. Literature has connected a stronger engineering identity with higher retention rates, improved climate perceptions, and better experiences for underrepresented groups in engineering [12]. Scholars have studied how engineering identity connects with self-efficacy, or individuals' beliefs about their own abilities to inform career decisions [10]. Strong evidence suggests the importance of identity formation through experiential education; however, there are many questions that still remain unanswered about how engineering programs can help create pathways for students to meaningfully participate and develop professional identity, especially at scale.

While experiential learning and engineering identity formation are important to the college experience, challenges remain for creating robust structures for students to reflect, conceptualize, and apply their learning. Kolb [13] recognized that the experiences themselves are not enough. His model describes a cyclical process that begins with a concrete experience, followed by reflection on that experience, conceptualization of learning from the experience, and finally active experimentation through the application of learnings to new experiences [13]-[16].

Background

Our project is set in the College of Engineering at the University of Michigan. There is a large undergraduate engineering population (>7,000 students) that is evenly divided between in-state and out-of-state students (including ~10% international students). The college has a long history of student engagement in experiential learning. Approximately 97% of graduating seniors in 2020 reported involvement with at least one curricular or co-curricular experiential learning opportunity (i.e., research, civic engagement, creative work, international experience, entrepreneurship, client project, or internship) [17] . Despite high engagement in these opportunities, both students and employers have expressed a need for support that assists students in reflecting on their development (e.g., engineering identity, professional competencies, and career aspirations) through their experiences and then communicating the significance of those experiences to employers and others [18].

Problem Statement

This initiative is creating a longitudinal research study of students as they move through the engineering curriculum, engage in various experiential learning opportunities, and develop professional competencies and engineering identity. Our hypothesis is that the resources and structures we have developed to promote experiential learning and reflection will support student development of professional competencies and engineering identity. Resources include a set of rubrics for 12 professional competencies often associated with experiential learning (teamwork, ethics, global & cultural awareness, etc.). Structures include our new web-based learning resource platform, which we believe provides important professional and identity development support to students who engage with it. Furthermore, we believe that this approach can be done at scale and provide meaningful support to the thousands of undergrads at our institution. Utilizing these supports and analyzing student outcomes will provide an exceptional opportunity to advance our understanding of the professional formation of engineering graduates, including underlying processes and mechanisms that support or constrain competency and engineering identity development.

Experiential Learning Competencies

The set of 12 professional competencies (see Table 1) were identified by faculty, staff and students. Definitions and rubrics for the competencies were grounded in engineering education literature [19]. The rubrics provide an overall competency definition as well as describe 3-4 dimensions (subcategories of the competency). The rubrics were presented to students, faculty and staff for review and revision and include examples of what students might do to explore a competency, engage with a competency, and finally explain their competency development to others [19]. Reflection prompts were also developed to guide student reflection, a process similarly described in Kolb's experiential learning model [13]. An example of one of the rubrics is included below in Figure 1.

Table 1: Targeted Professional Competencies.

Communication	*Ethics*	*Teamwork*
Creativity	*Grit/Persistence/Resilience*	*Global & Cultural Awareness*
Empathy	*Leadership*	*Risk — Ability to Accept and Manage*
Entrepreneurial Mindset	*Lifelong Learning*	*Systems Thinking — Authentic Problem Solving*

Leadership Definition: Cultivating an environment that collectively develops a shared purpose and inspiring others to work toward it.

	Exploring (1) *students might engage at this level in a 100/200-level course or in the first semester of a co-curricular	Engaging (2) *students might engage at this level in a 200/300-level course or in the first year of a co-curricular	Explaining (3) *students might engage at this level in a 300/400-level course or in extended co-curricular participation
Team Leadership	The student often defers to the opinions of others on a team and, when tasked with leading, employs few strategies to facilitate group work.	The student demonstrates an awareness of team dynamics and employs strategies to facilitate group work on occasion.	The student demonstrates an awareness of team dynamics, frequently employs strategies to facilitate group work, and demonstrates an ability to resolve conflict on the team.
Organizational Leadership	The student is aware of the goals of an organization and works to contribute to the achievement of those goals.	The student is able to explain the goals of an organization and works with others to contribute to the achievement of those goals.	The student demonstrates an ability to align goals, communicate expectations when they aren't being met, and facilitate the work of a group towards the goals of an organization.
Societal Leadership	The student gains exposure to considering the societal impact of their engineering work when making decisions as a leader.	The student demonstrates some understanding of the societal impact of their engineering work when making decisions as a leader.	The student understands and places emphasis on the societal impact of their engineering work when making decisions as a leader.

	Exploring (1)	Engaging (2)	Explaining (3)
Team Leadership	**Q:** Can you give an example of a situation where an engineer would have to use leadership skills in a team setting? **Q:** What does a leader look like? How might you identify a leader in a team setting? **I:** The student provides a personal definition of a leader and does not need to discuss how multiple individuals can be leaders on a team.	**Q:** Can you give an example of a situation where an engineer would have to use leadership skills in a team setting? **Q:** What does a leader look like? How might you identify a leader in a team setting? **I:** The student recognizes that leadership can be performed by multiple members of the team and acknowledges that they have the ability to perform leadership tasks.	**Q:** How do you define leadership in general and in your field? Do you think there are any differences between the two? **I:** The student discusses the differences between leadership in general and in their engineering field focusing on the many ways leadership tasks can be used in engineering group work.
Organizational Leadership	**Q:** What goals does your student organization have? How might you contribute to achieving them? **Q:** How might you describe an organization leader? What characteristics or habits do you think they should possess? **I:** The student can name the goals of the organization and reflects on their individual contributions to achieving those goals.	**Q:** What strategies do you use to encourage others in your organization to work towards the goals of your student organization? **Q:** How might you describe an organization leader? What characteristics or habits do you think they should possess? **I:** The student can name the goals of the organization and reflects on their ability to encourage others to work towards achieving those goals.	**Q:** How do you define leadership in general and in your student organization? Do you think there are any differences between the two? **Q:** How might you describe an organization leader? What characteristics or habits do you think they should possess? **I:** The student is able to articulate parallels and differences between their definition of leadership in general and in an organization.
Societal Leadership	**Q:** How important to you is considering the societal impact of your engineering work? **I:** The student acknowledges that considering the societal impact of their work is part of the engineering profession.	**Q:** How important to you is considering the societal impact of your engineering work? How might you go about accounting for your work's impact on society? **I:** The student acknowledges that considering the societal impact of their work is part of the engineering profession and demonstrates at least one instance where they have done so in their experiences.	**Q:** How important to you is considering the societal impact of your engineering work? How might you go about accounting for your work's impact on society? **I:** The student acknowledges that considering the societal impact of their work is part of the engineering profession and demonstrates an ability to consider the societal impact of their work and a commitment to do so in the future.

Figure 1: Rubric for leadership.

These resources are currently being used to encourage students to consider the need for professional competencies beyond the technical knowledge learned during their time in the college, but no formal requirement exists to develop any of the competencies. Beyond encouraging students to think about professional formation during their experience, it is our intention that these competency definitions will help create a common language around professional development at our university, aiding in the professional formation and communication of students' development across university and professional contexts. Already, the work has been shared with colleagues from our medical school and school of business as they embark to develop professional competences for their own contexts.

Web-based learning resource platform

Our next step was to link our existing experiential learning opportunities and resources to a web-based learning resource platform - *Spire*. This platform implements Kolb's experiential learning model [13] to support undergraduate students as they explore opportunities with intentionality, engage meaningfully in experiences, reflect on what they have learned, and communicate the value of the professional competencies they developed. Spire is a student-supportive proximal learning environment that facilitates metacognitive interventions designed to encourage students to leverage goal-setting and reflection to advance their competencies for career readiness. Spire was developed in partnership with the U-M Center for Academic Innovation and can be scaled to reach the majority of our 7,000+ undergraduates. It leverages an existing student success platform, eCoach [20], which focuses on supporting the student experience in classes through sharing personalized content and recommendations with students.

Spire guides students through the process of prioritizing which competencies they want to work on and identifying learning opportunities that can develop specific professional competencies. It also tracks student progress so that students can understand their strengths and areas for improvement as well as recognizes their growth over time. Spire collects data on student demographics and captures information on students' expectations, interests, goals, actions, and attainments. Figure 2 provides an overview of how Spire scaffolds the student experience to promote competency development and reflection. This structure is inspired by Kolb's iterative model emphasizing experience, reflection, conceptualization of learning from the experience, and application of learnings to new experiences [13]-[16].

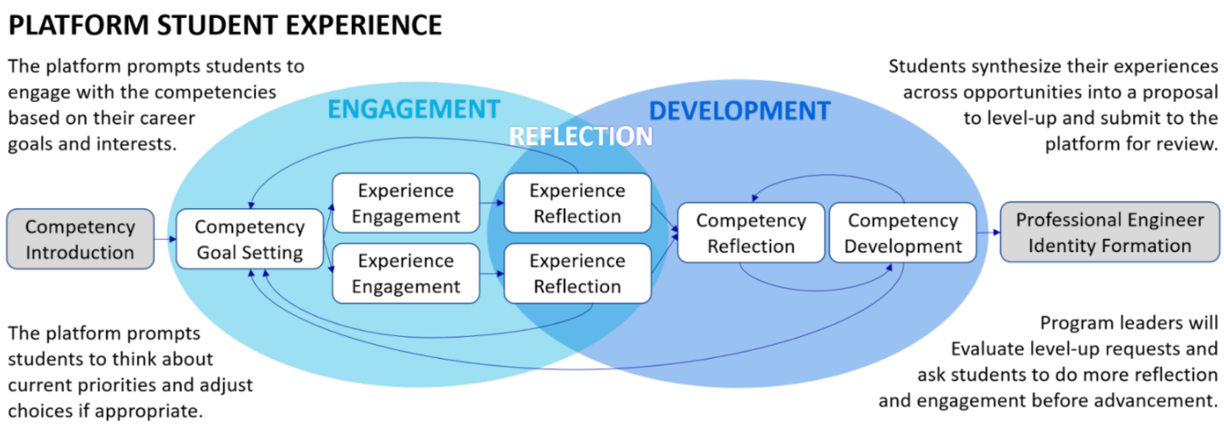

Figure 2. Schematic diagram of the Spire platform.

Beginning in the 2021-2022 academic year, Spire was introduced as part of incoming student orientation and applied within a recently revised first-year course that covers the breadth of opportunities available to engineers in both their education and their career. Students explore the foundations of the field and its influence on themselves and the world they live in. Students learn about the engineering majors offered at the college, and the types of career paths available for each engineering discipline. Students also identify their own interests and goals and discover the broader opportunities available through academic minors and co-curricular opportunities that align with their passions. The course reaches more than half of our incoming students (n = 800). In addition, we are establishing multiple curricular and co-curricular approaches for students to develop and communicate professional competencies within and apart from their ongoing engagement with Spire [18] (see Figure 2). Currently, over 1500 students have been onboarded to Spire. They each focus on three of the competencies (additional details below) and can choose from 40 different opportunities or create their own with guidance. For example, 442 of the students have selected leadership as a focus competency and there are 15 opportunities listed within Spire offering leadership development. Figure 3 below provides an example of Spire interface.

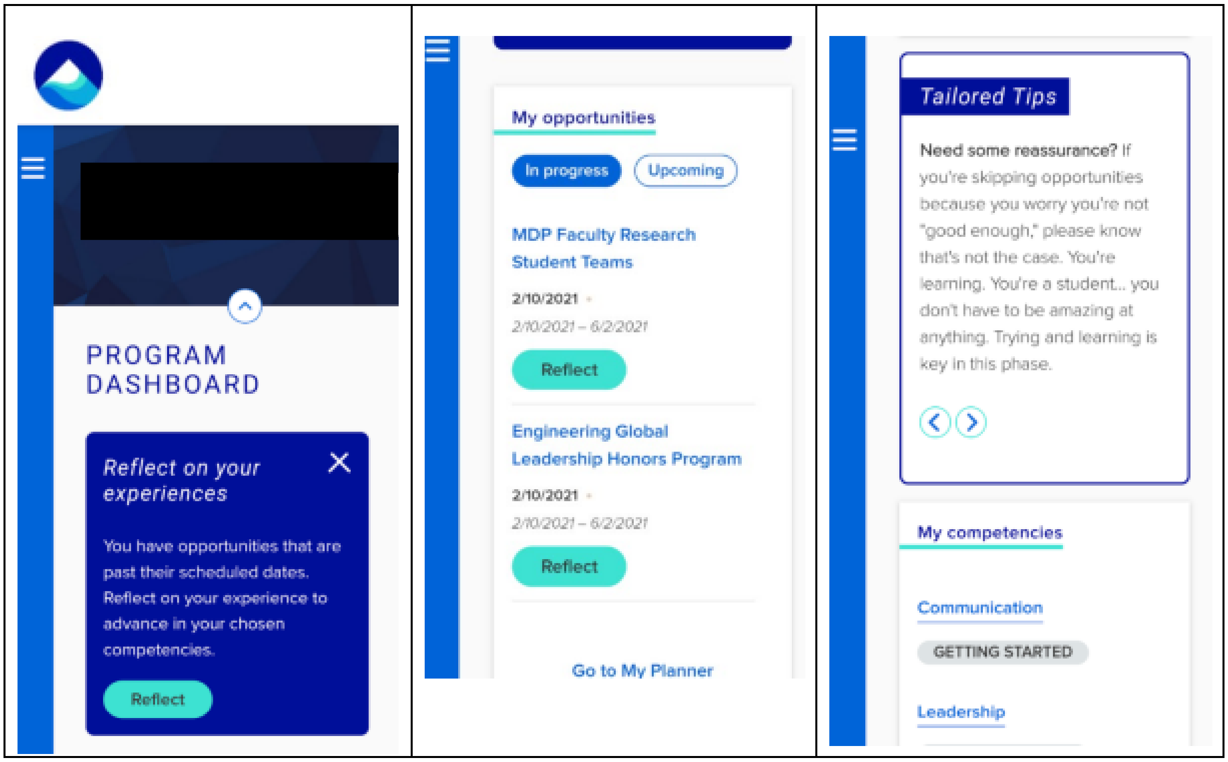

Figure 3. Spire student interface showing opportunities, planning, and reflection features.

Research Questions

The ultimate goal of this initiative is to identify pathways for student development of professional competencies and engineering identity. This will be accomplished by examining student engagement with the wide variety of available experiential learning opportunities and the newly developed platform, assessing student development of professional competencies and engineering identity, and evaluating implementation and measurement strategies. Exploring student engagement in this way will help us identify the most impactful approaches as we scale our efforts. Our research questions have two topic areas:

Development of Professional Competencies and Engineering Identity

1. How do students develop professional competencies and engineering identity through experiential learning opportunities?

Engagement with Experiential Learning Opportunities and Spire

2. How does the use of the newly developed platform scaffold professional competency and engineering identity development?

Research Plan

We are using a mixed-mode approach to collect data relevant to our research questions. The data being collected includes cross-sectional and longitudinal data from students in the college. Currently, we have collected some of the preliminary quantitative data for this study.

Quantitative data will include student outcomes data gathered through college-wide surveys and platform user data collection as well as quantified usage and engagement data from platform user analytics and college-wide surveys. Currently, we have collected and are analyzing initial onboarding data from students using Spire, and comparing these data to data from college-wide surveys. While we have not yet begun qualitative data collection, we plan to use focus groups and reflection prompt responses to better understand what features of Spire or other university support structures might support professional development.

Analytical Framework - Social Cognitive Career Theory

To help us examine the professional competency development and engineering identity formation of students engaging in experiential learning opportunities, we determined that we needed a framework by which to analyze our data. During the development of our Experiential Learning efforts and Spire, we considered several different analytical frameworks focused on student development. While we had used Kolb's experiential learning framework to design our learning resources and supports, we sought an analytical framework that aligned with our overarching goal of understanding the learning experiences of students and acknowledged the unique experiences of individuals' learning processes. As such, we looked for theories that accounted for the influence of student background and self-efficacy on opportunity choice and professional development, that accommodated scaffolding and reflection in line with experiential learning as described by Kolb's model [16], [15] , and that would allow us to explore a broad range of pathways to student outcomes (e.g., the twelve competencies and engineering identity).

Social Cognitive Career Theory (SCCT) aims to explain how career and academic interests develop, how career-relevant choices are made, and how performance outcomes are achieved [21]. Personal attributes (e.g., demographics, socioeconomic status), as well as current self-efficacy expectations, learning experiences, outcome expectations, environmental influencers, interests, and goals are the fundamental elements that predict actions and outcome development in SCCT. SCCT has been used as a framework in engineering education research to examine how variables in the model (e.g., self-efficacy, interest, and goals) relate to academic persistence in engineering across gender, race and ethnicity, and institution type [22]-[25]. Researchers have also used generalized SCCT survey instruments like the Engineering Affective Assessment (EAA) to examine engineering students' development in line with SCCT constructs of interest [26], [27].

Our study does not employ a standardized SCCT instrument to explore our data, instead we mapped the data collected through Spire and other college-wide surveys to SCCT constructs. Because Spire collects specific, time-bound data about students' interests, goals, and actions, we can explore specific pathways students take toward certain outcomes, and begin to understand professional development over time. In general, we conceptualize Spire as a proximal environmental influence that can enhance students' engagement and development of professional outcomes by facilitating reflection that connects their engagement and development. Figure 4 demonstrates the relationship between Spire and SCCT.

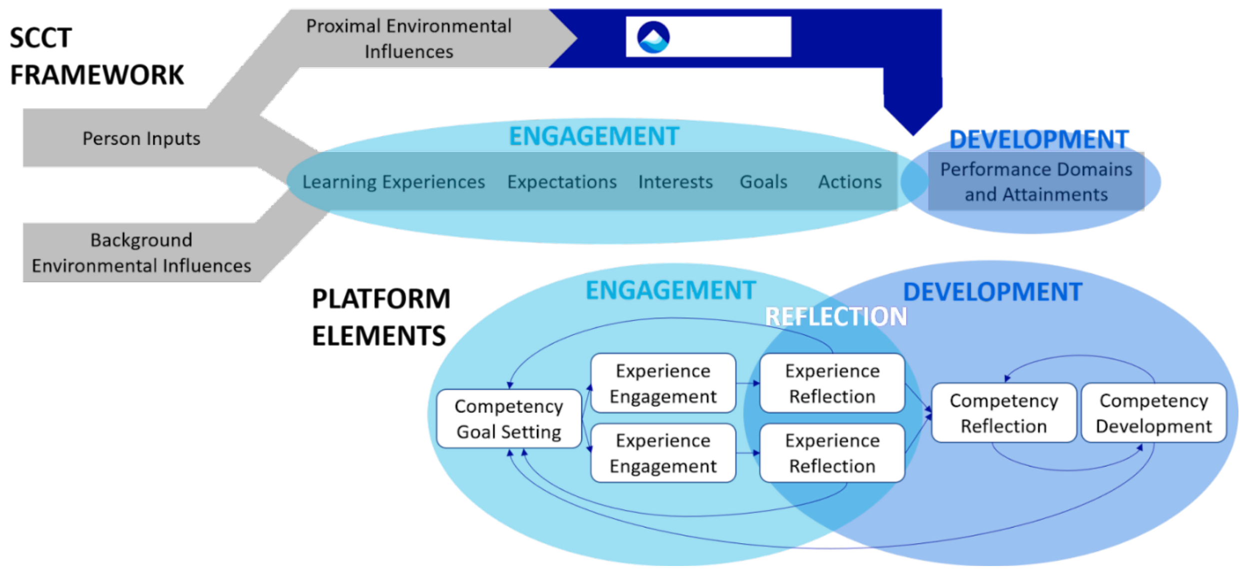

Figure 4. An adaptation of SCCT's relevant constructs in gray at the top. The constructs that are captured by SCCT's structure or data collection are indicated in shades of blue. The general process students experience within Spire is then demonstrated in the bottom half of the figure.

Initial Analyses & Discussion

We have begun collecting data from Spire participants and have found some preliminary patterns from the 2021-22 participants. So far, the students using Spire are mainly early-career students, primarily in the first year of their program likely because it is being introduced in large first-year program courses. The data presented represents responses from 911 students. 68% of respondents were of the male sex, 64% were first-year students by academic credit, 47% identified as white, and 23% as Asian.

For this paper, we explored data from how students responded to three questions about our twelve professional competencies: 1) What are your most important areas for growth? 2) What areas are most exciting to you personally? and 3) What areas might be most important for your career? Overall, we noticed some preliminary differences in how students prioritized the competencies based on the prompt. We also noticed some trends that might point to differences by demographics. We present the numeric patterns noticed here.

Figure 5 demonstrates differences in the competencies prioritized by students based on the prompt they were given. Students were allowed to select their top three competencies for each prompt. The top three responses for which competencies students felt were the most important areas for growth included Communication (21%), Creativity (16%), and Lifelong Learning (10%). Students similarly thought Creativity (22%) and Lifelong Learning (13%) were exciting personally. The other competency in the top three for competencies students felt were exciting was Systems Thinking (13%). For competencies students felt would be important for their career, Communication was by far the most frequent response (33%). Systems Thinking (14%) was next, with Teamwork (13%) and Creativity (13%) close behind.

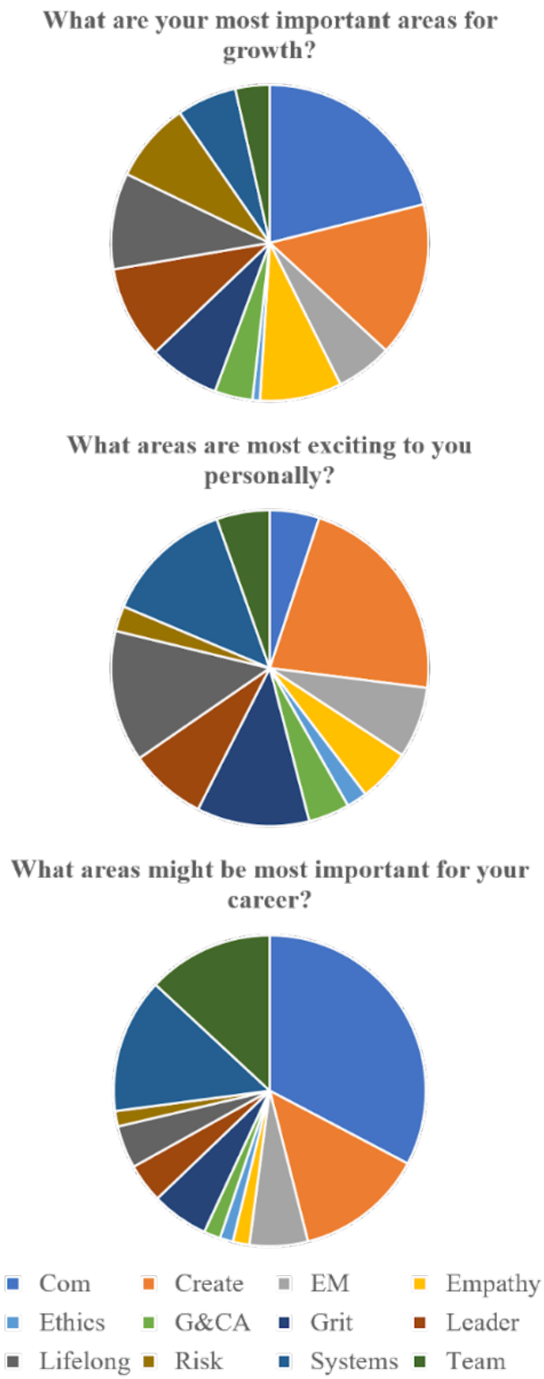

Figure 5. Differences in competency prioritization by student based on prompts.

We also explored the data based on the breakdowns of three pieces of demographic information from the students: sex, academic standing, and race/ethnicity. Figure 6 displays the data based on what the expected breakdown would be if participants are equally likely to select any of the competencies. Horizontal lines in the color matching the bars demonstrate the expected proportion of responses.

When looking at the data by sex, the most noticeable differences were observed for the question about competencies that students feel are important for growth and for their careers. Females appear to more frequently have indicated entrepreneurial mindset, global and cultural awareness, grit, risk, and systems thinking for competencies for growth. Females also more frequently selected global and cultural awareness as important for a career in engineering. Males reported teamwork more frequently as a growth competency, risk more frequently for a competency that is personally exciting, and creativity, ethics, and lifelong learning more frequently for competencies that were important for a career.

There were relatively fewer clear patterns in the academic standing data. First-year students (freshmen) appear to have reported lifelong learning more frequently as a growth competency, and communication more frequently as an exciting competency. Sophomores seem to more frequently have reported ethics as a growth competency and risk more frequently as an exciting competency. There were very few juniors and seniors in our dataset, and as such, we have not yet begun to explore patterns in their responses.

Finally, we looked at data by race/ethnicity (reported together). The category of all others in Figure 6 included respondents who selected Hispanic, Black/African American, 2+ Races, and Not Indicated due to the small numbers of students in these categories in our current data. White students appear to have more frequently reported global and cultural awareness as a growth competency, empathy and ethics as exciting competencies, and lifelong learning as an important career competency. Asian students seem to have more frequently reported ethics as a growth competency, and empathy as a career competency. Students in the All Others category seem to have more frequently reported global and cultural awareness as an important career competency.

These platform results are preliminary and exploratory, but we anticipate that the patterns we see in the data will help us understand the initial priorities of our students and improve our support efforts.

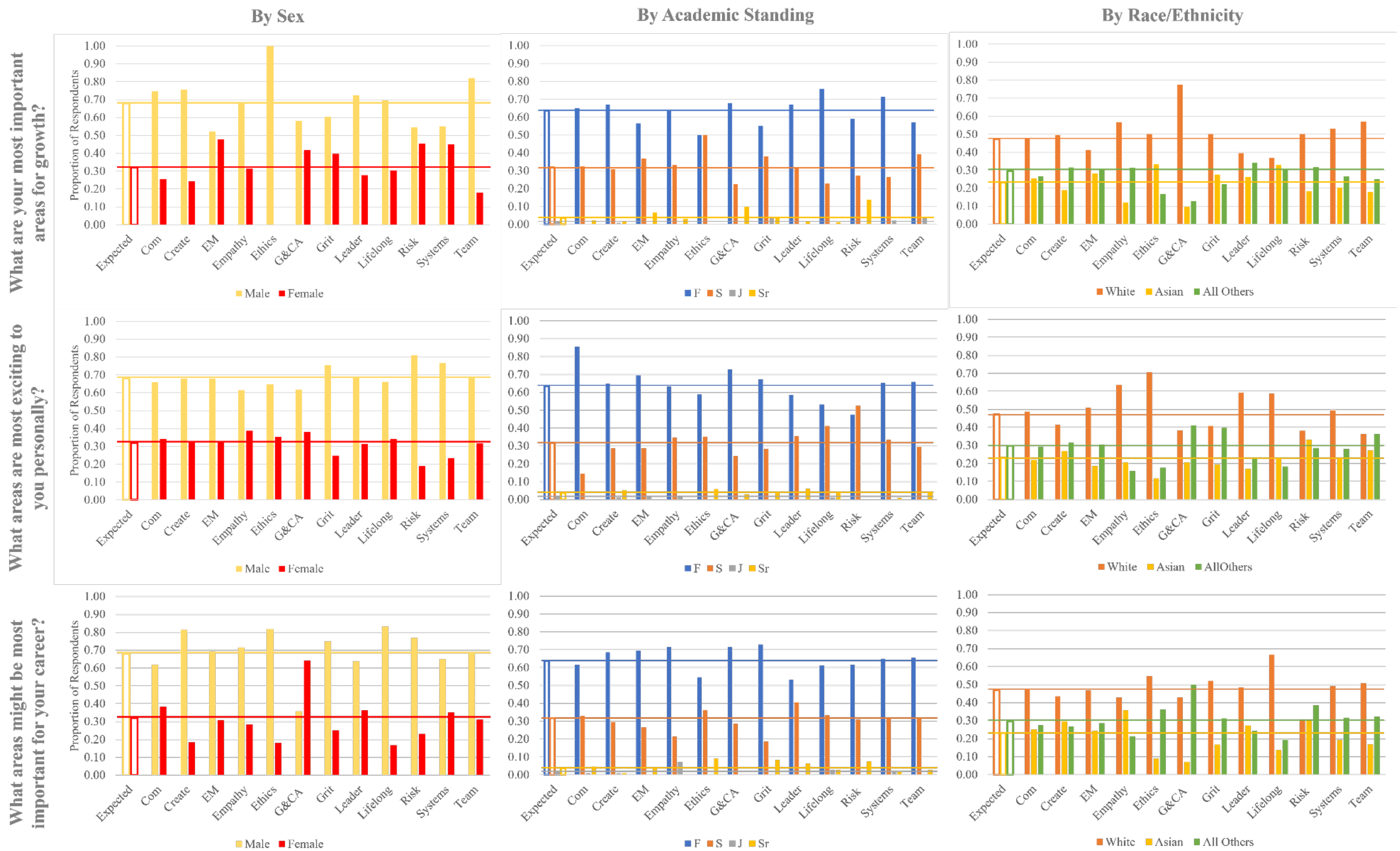

Figure 6. Data was collected on respondents' top three choices when prompted with questions about areas for growth, competencies that excite them, and competencies that might be important in a career. Data are broken down by sex, academic standing, and race/ethnicity.

Comparisons with Other Student Data

We only have very preliminary comparisons with other student data, but this will help guide our future work. For example, when we examine the top 4 competencies from the onboarding question about what students think will be important for their career, we can see that a majority of students graduating in 2022 (non-platform users) believed that these same competencies were highly important (Table 2). However, what we need to examine is how ready students are to apply these competencies. Our hypothesis is that platform users will be better prepared to utilize the development of their selected competencies in their careers.

Table 2: Initial comparisons.

Platform Onboarding - Top 4 items for Career (*n=800)*	***Number of Responses***	***2022 Senior Survey - Predict Importance in Career*** *(n=+/- 300)*	***Percent answering somewhat to extremely important***
Communication	255	Communication	98%
Creativity	108	Creativity	82%
Systems Thinking	14	Systems Thinking	97%
Teamwork	106	Teamwork	99%

Another area of comparison we intend to utilize is an annual survey of students at our institution which asks students to self-assess their proficiency across a set of competencies. This will be one way for us to examine how platform users and non-users self-assess the development over time. Table 3 provides an example of results for communication skills. As we gain more platform users, we will be able to make comparisons of reported growth between platform and non-platform users.

Table 3: 2022 Then and Now Comparisons for Communication

Percent Responding 'Good,' 'Very good,' or 'Excellent' in response to the prompt: *"Please rate your level of proficiency in the following areas when you started at this university and now."* (n=1300)		
	Then	***Now***
Written Communication Skills	72	85
Oral Communication Skills	64	84

Planned reflection activities and focus groups will help us further explore the student experience between platform users and non-users, giving us in-depth insights into features of Spire or other university support structures that might reinforce professional development. We will use patterns found in survey data to help us gather and analyze our qualitative data.

While we are still very much in the early stages of our work to examine pathways that support student development of professional competencies and engineering identity, we are encouraged by what we are learning from the preliminary results. There are clearly unique differences in how students view particular competencies and how that is understood based on demographics. We look forward to exploring data for longitudinal patterns as our resources and structures are used for longer in the college. Future analyses will help us better understand the student experience and if our new online platform is providing the support at scale to our students that we hope it will. We look forward to receiving input on our plans and early results.

References

[1] C. M. Itin, "Reasserting the Philosophy of Experiential Education as a Vehicle for Change in the 21st Century," *J. Exp. Educ.*, vol. 22, no. 2, pp. 91–98, 1999.

[2] J. Cantor, "Experiential Learning in Higher Education: Linking Classroom and Community," 1995.

[3] R. Graham, "The Global State of the Art in Engineering Education," Massachusetts Institute of Technology, Cambridge, MA, 2018. Accessed: Oct. 04, 2018. [Online]. Available: file://engin-storage.m.storage.umich.edu/engin-storage/jcallew/windat.v2/Documents/Conferences/ASEE/2019/MIT_NEET_GlobalStateEngineeringEducation2018.pdf

[4] L. Harrisberger, "Experiential Learning in Engineering Education," ERIC Clearinghouse, 1976.

[5] D. R. Fisher, A. Bag, and S. Sarma, "Developing Professional Skills in Undergraduate Engineering Students Through Cocurricular Involvement," *J Stud Aff Res Pr.*, vol. 54, no. 3, pp. 286–302, 2017.

[6] D. R. Simmons, E. G. Creamer, and R. Yu, "Involvement in Out of Class Activities: A Mixed Research Synthesis Comparing Outcomes of Engineering to Non- engineering Undergraduate Students," *J STEM Educ Innov Res*, vol. 18, no. 2, pp. 10–16, 2017.

[7] A. J. Conger, B. Gilchrist, J. P. Holloway, A. Huang-Saad, and T. H. Zurbuchen, "Experiential Learning Programs for the Future of Engineering Education," in *2010 IEEE Transform. Eng. Educ. Creat. Interdiscip. Ski. Complex Glob. Environ.*, 2010, pp. 7–13.

[8] J. M. Millunchick, E. Brennan-Wydra, T. Henderson, A. Johnson, and C. J. Finelli, "The Role of College Knowledge and Proactive Behavior on Participation in Cocurricular Activities," *J Eng Educ*, vol. 110, pp. 114–142, 2021.

[9] B. Johnson and J. Main, "The Influence of Experiential Learning on Student Professional Development: A Literature Review," presented at the American Society for Engineering Education Annual Conference and Exposition, 2020.

[10] A. Godwin, G. Potvin, Z. Hazari, and R. Lock, "Identity, Critical Agency, and Engineering: An Affective Model for Predicting Engineering as a Career Choice," *J Eng Educ*, vol. 105, no. 2, pp. 312–340, 2016.

[11] K. L. Meyers, M. W. Ohland, A. L. Pawley, S. E. Silliman, and K. A. Smith, "Factors Relating to Engineering Identity," *Glob J Eng Educ*, vol. 14, no. 1, pp. 119–131, 2012.

[12] J. R. Morelock, "A Systematic Literature Review of Engineering Identity: Definitions, Factors, and Interventions Affecting Development, and Means of Measurement," *Eur J Eng Educ*, vol. 42, no. 6, pp. 1240–1262, 2017.

[13] D. A. Kolb, R. E. Boyatzis, and C. Mainemelis, "Experiential Learning Theory: Previous Research and New Directions," in *Perspectives on Thinking, Learning, and Cognitive Styles*, 3rd ed., Mahwah, NH: Routledge, 2011, pp. 227–249.

[14] A. Y. Kolb and Kolb, D.A., “Experiential Learning Theory: A Dynamic, Holistic Approach to Management Learning, Education and Development,” in *The SAGE Handbook of Management Learning, Education and Development*, 2009, pp. 42–68.
[15] D. A. Kolb, “The Process of Experiential Learning,” in *Experiential Learning: experience as the source of learning and development*, Englewood Cliffs, NH: Prentice Hall, 1984, pp. 20–38.
[16] D. A. Kolb, *Experiential Learning Experience as the Source of Learning and Development*, Second Edition. Upper Saddle River, New Jersey: Pearson Education Inc., 2015.
[17] Office of the Provost, “Engaged Learning in Engineering: Engaged Learning Census (ELC) Undergraduate Class of Fiscal Year 2020,” University of Michigan-Ann Arbor, 2020.
[18] J. H. Callewaert, J. M. Millunchick, C. S. E. Jamison, and K. C. Jiang, “Assessing and Communicating Professional Competency Development Through Experiential Learning,” presented at the American Society for Engineering Annual Conference & Exposition, 2021.
[19] C. S. E. Woodcock, J. H. Callewaert, and J. M. Millunchick, “Synthesizing Definitions of Professional Competencies Linked to Experiential Learning in Engineering Education: A Literature Review,” *J High Educ Theory Pr.*, vol. 21, no. 4, pp. 123–146, 2021.
[20] R. L. Matz *et al.*, “Analyzing the Efficacy of ECoach in Supporting Gateway Course Success through Tailored Support,” presented at the Learning Analytics and Knowledge Conference, 2021.
[21] R. W. Lent and S. D. Brown, “Social Cognitive Model of Career Self-Management: Toward a Unifying View of Adaptive Career Behavior Across the Life Span,” *J Couns Psychol*, vol. 60, no. 4, pp. 557–568, 2013, doi: 10.1037/a0033446.
[22] H. S. Lee, L. Y. Flores, R. L. Navarro, and M. Kanagui-Muñoz, “A Longitudinal Test of Social Cognitive Career Theory’s Academic Persistence Model Among Latino/a and White Men and Women Engineering Students,” *J Vocat Behav*, vol. 88, pp. 95–103, 2015, doi: 0.1016/j.jvb.2015.02.003.
[23] M. Inda, C. Rodríguez, and J. V. Peña, “Gender Differences in Applying Social Cognitive Career Theory in Engineering Students,” *J Vocat Behav*, vol. 83, no. 3, pp. 346–355, 2013, doi: 10.1016/j.jvb.2013.06.010.
[24] M. I. Borrego, D. B. Knight, K. Gibbs, and E. Crede, “Pursuing Graduate Study: Factors Underlying Undergraduate Engineering Students’ Decisions,” *J Eng Educ*, vol. 107, no. 1, pp. 140–163, 2018, doi: 10.1002/jee.20185.
[25] R. W. Lent *et al.*, “Social Cognitive Predictors of Academic Interests and Goals in Engineering: Utility for Women and Students at Historically Black Universities,” *J Couns Psychol*, vol. 52, no. 1, 2005.
[26] R. A. Atadero, K. E. Rambo-Hernandez, and M. M. Balgopal, “Using Social Cognitive Career Theory to Assess Student Outcomes of Group Design Projects in Statics: SCCT and Student Outcomes of Statics Projects,” *J Eng Educ*, vol. 104, no. 1, pp. 55–73, 2015, doi: 10.1002/jee.20063.
[27] J. Peña-Calvo, M. Inda-Caro, C. Rodríguez-Menéndez, and C. Fernández-García, “Perceived Supports and Barriers for Career Development for Second-Year STEM Students,” *J Eng Educ*, vol. 105, no. 2, pp. 341–365, 2016, doi: 10.1002/jee.20115.